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Estimation of By Catch in the Commercial Fishery for Greenland halibut at West Greenland based on Survey Data

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Abstract

The by catch in the commercial fishery for Greenland halibut in NAFO Div. 1CD was estimated based on information from ground fish surveys conducted by Greenland Institute of Natural Resources in the same area as the commercial fishery. The survey is conducted with a trawl with 30 mm in the cod end while the minimum mesh size in the cod end in the commercial trawls is 140 mm and the survey catches are converted to potential commercial by catches. The conversion is based on a number of assumptions and the results should be considered as indicative. The total by-catch in weight is estimated to be 13% of the total catch of Greenland halibut. *Macrourus berglax* is the most abundant by catch species and constituted 3.2% of the weight of Greenland halibut followed by *Antiomora rostrata* (2.7%), *Alepocephalus agassizzi* (2.0%) and *Hydrolagus affinis* (1.2%). None of the remaining species constituted more than 1% of the weight of the Greenland halibut catches. The impact of the fishery for Greenland halibut in Div. 1CD on the stocks of the by-catch species seems, however, to be limited. The by-catch in Div. 0B is at the same level as in Div. 1CD.

Introduction

By catch in the commercial fisheries has become an increasing issue and is an important parameter in evaluation of the sustainability of the fisheries. The information about by catch in the commercial fishery for Greenland halibut (*Reinhardtius hippoglossoides*) at West Greenland (NAFO SA 1) is limited and the information in the log books is sparse and there is no direct information from other sources.

In the present paper the by catch in the commercial fishery for Greenland halibut in NAFO Div. 1CD is estimated based on information from ground fish surveys conducted by Greenland Institute of Natural Resources in the same area as the commercial fishery. The survey is conducted with a trawl with 30 mm in the cod end while the minimum mesh size in the cod end is 140 mm and the survey catches is converted to potential commercial by catches.

It has not been possible to estimate the by catch in the Baffin Bay (NAFO Div. 1AB) due to too few survey hauls in the area and at depths where the commercial fishery takes place to make reasonable by catch estimates. The most abundant species in the by catches in Div. 1CD *Macrourus berglax*, *Antiomora rostrata*, *Alepocephalus agassizzi* and *Hydrolagus affinis* were, however, ether total absent or very rare in the survey catches in Div. 1AB, where the commercial by catch probably is dominated by *Amblyraja hyperbore*a and *Anarhichas denticulatus*.

Material and methods

The survey takes place in September and covers NAFO Div. 1CD at depths between 400 and 1500 m, which is the same area as the commercial fishery is conducted. 90% of the commercial trawl hauls takes place at depths > 941 m (mean 1096 m). Survey trawl hauls > 941 m from 2010-2014 are selected for analysis, 178 hauls in total. The survey is assumed to have a catchability on 1 *i.e*. all fish in the trawled area are caught.

The survey is conducted with 30 mm mesh in the cod end while the minimum mesh size is 140 mm in the commercial fishery. There are no selection data available for the relevant species. In order to convert survey catches to commercial catches the selection of round fish is set to 3 times mesh size *i.e*. 42 cm and 1.5 times mesh size for rays and skates *i.e*. 21 cm as a rule of thumb. There are no flatfish observed in the survey catches at the depth rang used in the analysis. The minimum landing size for Greenland halibut is 42 cm and it is considered to be fully selected to the commercial gear at that length.

A number of fish species caught in the survey are considered to be pelagic, and hence only be caught while the trawl is set or hauled, and/or too small (Whitehead et al. 1984) to be taken in a 140 mm trawl, or having a body shape that should allow them to escape a 140 mm trawl. These species are excluded from the estimations (Table 1).

Among the remaining species there are specimens that are too small to be selected in a 140 mm trawl. The weight of these small fish is estimated by length-weight relationships obtained from the literature or Fish Base. The estimated weight of small fish is subtracted from the total survey catch weight of the species and the weight of the remaining "large" fish is given as percentage of the survey catch weight of Greenland halibut > 41 cm.

Grenadiers are measured as Anal Fin Length in the survey but is converted to total length (Jørgensen 1996).

Results

In total 90 species or species groups were caught in the surveys (Table 1). 62 of them are considered to be pelagic and hence only be caught while the trawl is set or hauled and/or too small (Whitehead et al. 1984) to be selected in a 140 mm trawl, or having a body shape that should allow them to escape a 140 mm trawl (eg: *Anoptopterus pharo*, *Eurypharynx pelecanoides*, *Sacopharynx ampullaceus*, *Serrivomer beani, Synaphobranchs kaupi* and *Lycodes species*.

The by catch in weight is estimated to constitute 13.0% of the weight of Greenland halibut > 41 cm (Table 2). *Macrourus berglax* is the most abundant by catch species. The length in the survey catches ranged from 14-102 cm and the weight of fish < 42 cm was estimated to 212.0 kg, while the weight of fish > 41 cm was estimated to 842.5 kg, which is 3.22% of the weight of Greenland halibut > 41 cm. The second most abundant species was *Antiomora rostrata* that constituted 2.70% of the weight of Greenland halibut, followed by *Alepocephalus agassizzi* (2.02%) and *Hydrolagus affinis* (1.19%). None of the remaining species constituted more than 1% of the weight of Greenland halibut (Table 2).

Discussion

The estimations are based on 178 survey trawl hauls conducted in the area and at depths where the commercial fishery for Greenland halibut in NAFO Div. 1CD takes place which gives a reasonable good coverage of the area.

The estimations are based on a number of assumptions and the results should be considered as indicative:

1) There are no selection parameters available for the relevant species and a knife edge selection has been used for all species. Further, the same knife edge selection on 42 cm and 21 cm has been applied for roundfish and rays and skates, respectively, despite that fish has a very different shape as *eg. Notacanthus chemnitzii, Macrourus berglax* and *Antimora rostrata.*

2) The weight of small fish < 42 (roundfish) and < 21 cm (skates and rays) is estimated from length/weight relationships from the literature and are usually not from the survey area, which could either underestimate or overestimate the weight of small fish.

3) Grenadier lengths are converted from Anal Fin length to total length. This convention is, however, based on data from the area (Jørgensen 1996).

4) A 42 cm Greenland halibut, which is the minimum landing size, is considered to be fully selected to the commercial gear. This assumption is probably acceptable. The discard from the commercial fishery is reported to be < 1% (Jørgensen and Treble 2015) and must include damaged fish that cannot be processed.

The selection in a commercial trawl that has been fishing for hours and hence could contain several tons Greenland halibut is probably not fully effective which implies that some small fish including some pelagic species distributed close to the bottom are caught in the trawl. The proportion of this type of catch can only be estimated by direct analysis of the commercial catches.

The fishery for Greenland halibut at West Greenland is conducted in a rather small area compared with the much wider distribution area of almost all spices observed in the area (Whitehead et al. 1986), and many of the species are at the rim of their distribution area (Jørgensen et al. 2011), suggesting that stock dynamic processes outside the fishing area might influence the dynamics of these stocks within the fishing area. A study by Jørgensen et al. (2014) showed hence that the effect of the Greenland halibut fishery in Div. 1CD on the abundance of non-commercial species is limited while a number of species decrease in mean size. During the period 1988-2011 *Macrourus berglax* showed an increase in abundance while the mean sizes decreased about 15%. The changes were, however, not statistically significant. The second most abundant by catch species *Antiomora rostrata* showed a statistically significant increase in abundance (p=0.001) while the mean size decreased by about 30% (p=0.001). The abundance of *Centrocyllium fabrici* decreased statistically insignificant (0.05 level) while the means size decreased 26% (p=0.05), There is no information on *Alepocephalus agassizzi* and *Hydrolagus affinis* in the paper.

In SA 0 (Canadian waters) the by-catch is estimated by observers on board and the observer program covers most of the catches. In 2015 the by-catch in the trawl fishery in Div. 0B was estimated at 16.3% of the Greenland halibut catches which is in good agreement with what is estimated for Div. 1CD. The by-catch in the trawl fishery in Div. 0A was estimated at 6.7%. Greenland shark, skates and roughhead grenadier were the dominant by-catch species in SA0 (Jørgensen and Treble 2016) .

Table 1. Species caught in survey hauls > 941 m. Species marked * is consider to be pelagic, having too small a maximum size or having a body shape that does that they are not selected by a 140 mm trawl.

GINR code	Name		Status	mindepth	maxdepth
ALA	Alepocephalus	agassizzi		981	1493
ALB	Alepocephalus	bairdii		1251	1323
RFL	Amblyraja	fyllae		945	1361
CAD	Anarhichas	denticulatus		949	1483
CAA	Anarhichas	lupus		1148	1148
CAS	Anarhichas	minor		1188	1188
ANC	Anopologaster	cornuta	*	965	1464
ATP	Anoptopterus	pharo	*	1284	1456
ANT	Antimora	rostrata		942	1493
ARZ	Arctozenus	rissoi	*	1041	1348
AGH	Argyropelecus	hemigymnus	*	1129	1129
BAM	Bajacalifornia	megalops		989	1467
BAT	Bathylagus	euryops	*	942	1493
BAS	Bathylagus	sp.	*	949	1361
BSP	Bathyraja	spinicauda		951	1262
BEG	Benthosema	glaciale	*	942	1493
BOA	Borostomias	antarcticus	*	945	1493
CFB	Centroscyllium	fabricii		942	1461
CHO	Ceratias	holboelli	*	1133	1262
CRT	Ceratidae		*	1143	1143
CHA	Chauliodus	sloani	*	942	1483
CHH	Chiasmodon	harteli	*	966	1456
CHN	Chiasmodon	niger	*	945	1464
CBB	Coryphaenoides	brevibarbis	*	1131	1493
CGR	Coryphaenoides	gytheri	*	942	1493
RNG	Coryphaenoides	rupestris		942	1493
COM	Cottunculus	microps	*	973	1285
COT	Cottunculus	thomsonii	*	945	1356
LUM	Cyclopterus	lumpus	*	957	1375
CYB	Cyclothone	braueri	*	1104	1454
CLM	Cyclothone	microdon	*	951	1493
EUR	Eurypharynx	pelecanoides	*	1097	1446
ONA	Gaidropsarus	argentatus		1133	1361
ONN	Gaidropsarus	ensis		945	1493
GOB	Gonostoma	bathyphilum	*	951	1467
GOS	Gonostoma	sp.	*	1157	1157
HOA	Holtbyrnia	anomala	*	955	1483
HMC	Holtbyrnia	macrops	*	945	1052
HAF	Hydrolagus	affinis		1240	1493
LYD	Lampanyctus	crocodilus	*	1335	1335

LAI	Lampanyctus	intricarius	*	942	1228
LMC	Lampanyctus	macdonaldi	*	942	1493
LSP	Lampanyctus	sp.	*	1155	1155
LEP	Lepidion	eques		942	1446
LOA	Lophodoles	alanthogantus	*	1139	1343
LYS	Lycenchelys	sarsi	*	955	979
LYN	Lycodes	eudipleurostictus	*	1251	1268
LMA	Lycodes	macallister	*	1182	1210
LPA	Lycodes	paamiuti	*	945	1343
ELZ	Lycodes	sp.	*	960	960
LYT	Lycodes	terraenova	*	1106	1106
LYM	Lycodonus	mirabilis	*	1122	1284
RHG	Macrourus	berglax		942	1493
MAA	Magnisudis	atlantica	*	945	1464
MAL	Malacosteus	niger	*	955	1268
MMI	Maulisia	microlepis	*	1026	1446
MBE	Melanolagus	bericoides	*	964	1308
MYC	Myctophidae		*	1356	1356
MYP	Myctophum	punctatum	*	942	1483
MYI	Myxine	ios	*	1021	1021
NEM	Nemichthys	scolopaceus	*	1152	1220
NZA	Nezumia	aequalis		986	986
NZB	Nezumia	bairdii		945	1297
PMO	Normichthys	operosa	*	1086	1086
NOT	Notacanthus	chemnitzii		942	1493
NOK	Notoscopelus	kroyeri	*	957	1430
PAC	Paraliparis	copei	*	964	1450
PAG	Paraliparis	garmani	*	1375	1375
PSP	Paraliparis	sp.	*	1079	1079
POL	Polyacanthonotus	rissoanus	*	949	1467
RBI	Raja	bigelowi		969	1368
RJJ	Raja	jenseni		1430	1430
RLT	Raja	lintea		1118	1192
SKA	Raja.	sp.		1189	1266
RBT	Rajella	bathyphila		1046	1340
GHL	Reinhardtius	hippoglossoides		942	1943
RHD	Rhadinestes	decimus	*	1335	1335
RHO	Rhodichthys	regina	*	1026	1026
RDL	Rondeletia	loricata	*	1356	1356
RAT	Rouleina	attrita	*	1192	1268
ROM	Rouleina	maderensis	*	1028	1276
SAC	Sacopharynx	ampullaceus	*	1356	1356
SCO	Scopelosaurus	lepidus	*	942	1493
REB	Sebastes	mentella		957	1483

SEK	Serasia	koefoedi	*	969	1182
SER	Serrivomer	beani	*	949	1483
STO	Stomias	boa	*	945	1483
SYN	Synaphobranchs	kaupi	*	942	1483
TRA	Trachyrhynchus	murrayi		945	1191
XEC	Xenodermichthys	copei	*	1041	1493

Table 2. Species potential selected in a 140 mm trawl. Length range is the length ranged observed in the survey trawl. Wight small is the weight of fish < 42 cm (roundfish) or < 21 cm (rays and skates) estimated by a length/weight relationship. Ref. reference to length/weight relationship. Weight large is total survey catch weight subtracted weight of small fish. Pct. is weight of large fish in percentage of weight of Greenland halibut > 41 cm. Weight in kg.

GINR code	Name		Length range	Weight small	Weight large	Pct.	Length/Weight	Ref.
ALA	Alepocephalus	agassizzi	4-77	154.4	527.1	2.02	(0.00724*l^3.06)/1000	FishBase
ALB	Alepocephalus	bairdii	14-33	1.2				
RFL	Amblyraja	fyllae	35-56		7.0	0.03		
CAD	Anarhichas	denticulatus	7-120	43.5	234.6	0.90	(0.078*l^2.62)/1000	FishBase
CAA	Anarhichas	lupus	6	0				
CAS	Anarhichas	minor	52		2.4	0.01		
ANT	Antimora	rostrata	9-70	620.4	706.6	2.70	(0.0008*l^3.58)/1000	FishBase
BAM	Bajacalifornia	megalops	17-32	1.4				
BSP	Bathyraja	spinicauda	74-162		97.8	0.37		
CFB	Centroscyllium	fabricii	42-84		231.4	0.88		
RNG	Coryphaenoides	rupestris	11-50	79.1	99.6		(0.0192l^2.513)/1000	Jørgensen 1996
ONA	Gaidropsarus	argentatus	9-37	0.7				
ONN	Gaidropsarus	ensis	10-48	35.9	43.3	0.17	(0.0112*l^2.836)/1000	FisBase
HAF	Hydrolagus	affinis	78-131		310.7	1.19		
LEP	Lepidion	eques	17-33	3.0				
RHG	Macrourus	berglax	14-102	212.0	842.5	3.22	(0.00421l^3.099)/1000	Jørgensen 1996
NZA	Nezumia	aequalis	25	0.2				
NZB	Nezumia	bairdii	20-47		0.6	0.00		1 obs >41
NOT	Notacanthus	chemnitzii	31-107	5.6	253.8	0.97	(0.000*l^3.5)/1000	Paz. X and E. Román. 1997
RBI	Raja	bigelowi	22-53		1.1	0.00		
RJJ	Raja	jenseni	102		10.3	0.04		
RLT	Raja	lintea	71-80		6.0	0.02		
RBT	Rajella	bathyphila	24-103		16.9	0.06		
GHL	Reinhardtius	hippoglossoides	5-107	664.9	26147.0		(0.078*l^2.62)/1000	J. Boje GINR
REB	Sebastes	mentella	25-41	17.5				
TRA	Trachyrhynchus	murrayi	21-49	1.8	7.8	0.03	(0.00102l^3.06)/1000	FishBase
Total						13.0%		

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